Figure *1* a

Figure *1* b

Figure *1* c

Figure 2 a Figure 2 b Figure 2 c

Effects of Desiccation on the Survival of the Marine Snail *Batillaria minima* (Gmelin)

BY

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(1 Text figure)

INTRODUCTION

THE MARINE INTERTIDAL SNAIL, *Batillaria minima* (GMELIN, 1791) from Florida, U.S.A. is regularly exposed to long periods of drying. MOSELEY & NOLLEN (1973) noted that this ability to withstand desiccation allows the snails to be readily shipped. *Batillaria minima* is the intermediate host of a variety of larval trematodes including the eyefluke, *Philophthalmus hegeneri* Penner & Fried, 1963 and the avian schistosome, *Ornithobilharzia canaliculata* (Rudolphi, 1819).

SCHAEFER *et al.* (1970) presented some evidence that larval trematodes may decrease the ability of *Nassarius obsoletus* (Say, 1822) to resist desiccation. Preliminary observations in our laboratory have revealed that *Batillaria minima* snails which emit *Ornithobilharzia canaliculata* cercariae on isolation are less able to resist the effects of desiccation than snails which do not emit cercariae. The purpose of this study was to determine the effects of desiccation on the survival of *B. minima* snails which did not emit cercariae on isolation.

MATERIALS AND METHODS

Snails collected in Clearwater Harbor, Largo, Florida by a supplier were mailed to Easton, Pennsylvania between November 1973 and May 1974. Upon receipt, snails were isolated individually in artificial sea water (30‰) for 1 to 24 hours. Only snails which did not emit cercariae on isolation were used in desiccation experiments. Snails, 10 to 20 mm in shell length, were randomly selected for desiccation experiments to eliminate size as a variable, and were blotted dry with paper toweling prior to their use.

Eleven groups each containing 25 snails were used to study desiccation at room temperature (ca. 21-23° C). Each group was placed in an open petri dish, and a group was examined once and then discarded. Examination was made from 3 to 15 days postdrying by immersing a petri dish in a finger bowl containing about 200 ml sea water. Snails which showed no movement and did not respond to a probe within 2 hr postimmersion were considered dead.

Nine groups each containing 15 snails were used to study desiccation at a constant temperature and low humidity. To achieve a low humidity, snails in open petri dishes were placed in a sealed desiccator containing anhydrous $CaSO_4$. The desiccator was maintained at 23° C in an incubator. Examination was made from 5 to 10 days postdrying as described previously.

To assess the effects of high temperature and low humidity, 10 groups each consisting of 15 snails were placed in a sealed desiccator and maintained in an incubator at 37.5° C. Snails were examined from 1 to 10 days postdrying as described previously.

To determine the effects of a damaged shell on snail survival in a sealed desiccator at 37.5° C, a 2 × 0.5 mm hole was filed through a snail's shell near the apex. Five groups each consisting of 10 "filed snails" were examined from 1 to 3 days postdrying.

RESULTS

Results of desiccation experiments are presented in Figure 1 and reveal that 50% of the snails maintained in open petri dishes at room temperature (closed triangles) survived 13 days. Snails maintained in a desiccator at 37.5° C (closed circles) showed 50% survival for 3 to 4 days. "Filed snails" (open circles) were all dead within 3 days. Survival of snails maintained at 23° C in a desiccator (open triangles) was essentially similar to that observed in snails maintained in open petri dishes at room temperature.

Figure 1

Effects of desiccation on the survival of *Batillaria minima*. ▲ represent snails maintained at room temperature (about 21° to 23°) in open petri dishes; △ represent snails maintained in a desiccator at 23° C; ● represent snails maintained in a desiccator at 37.5° C; ○ represent "filed snails" maintained in a desiccator at 37.5° C.

DISCUSSION

Elevated temperatures adversely affect the ability of this snail to withstand desiccation, observations which are in accord with the findings of SCHAEFER *et al.* (1968) on *Nassarius obsoletus*. Maximum survival for *N. obsoletus* under conditions of experimental desiccation was 8 days at 11° C, about 4 days at 25° C and less than 2 days at 37° C (SCHAEFER *et al., op. cit.*). Data presented herein suggest that *Batillaria minima* is more tolerant to experimental desiccation than is *N. obsoletus*.

Batillaria minima maintained in a sealed desiccator at 23° C showed similar survival values as those maintained in open air at room temperature. Based on our experimental design these findings are not unusual since KENSLER (1967) has indicated that air stillness in a sealed desiccator may counteract the effects of the lower humidity.

Observations on our "filed snails" indicate that damage to the shell adversely affects the ability of this operculate snail to resist desiccation.

Numerous studies on the effects of desiccation on snails have been reported (reviewed by SCHAEFER *et al.*, 1968). Standardization procedures in these studies have generally been lacking, and many investigators have failed to control the numerous variables involved in desiccation work.

SCHAEFER *et al.* (1970) presented considerable data on %weight loss (water loss) in *Nassarius obsoletus* experimentally desiccated at 37° C. These data should be interpreted with caution since their measurements obviously include observations on dead snails. Although maximal survival for *N. obsoletus* was stated to be about 30–34 hr at 37° C (SCHAEFER *et al.*, 1968), they present water loss data up to 8 and 9 days (SCHAEFER *et al.*, 1970).

Contrary to WAGNER's (1960) observations we have had limited success maintaining *Batillaria minima* in aerated sea water with or without food additives at either 12° or 23° C. We usually immerse snails in sea water for several hours following dry storage at room temperature for 2 to 3 days. Under these conditions snails survive and are active during immersion for at least 1 to 2 months.

ACKNOWLEDGMENTS

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The Settlement and Distribution of Marine Organisms Fouling a Seawater Pipe System[1,2]

BY

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(1 Plate; 3 Text figures)

INTRODUCTION

THE SEAWATER PIPE SYSTEM of the Marine Sciences Research Laboratory (M.S.R.L.), Logy Bay, Newfoundland, was in continuous operation between the fall of 1967 and the completion of sampling in December 1971. During this time, organisms originating from the sub-Arctic waters of this region inhabited the unique environment of the seawater system. By studying these fouling communities, some basic information on fouling in both seawater pipe systems and sub-Arctic waters was obtained. There is little past literature detailing fouling in either of these two conditions. The only pertinent fouling study in Newfoundland waters was carried out by DEPALMA (1969) who identifies thirty-one species of primary fouling organisms.

METHODS

Wherever possible, direct examination of the seawater system was carried out. Several sections of the pipe were removed, fixed in neutralized formalin, and preserved in isopropyl alcohol. Counts and identifications were made of all fauna in each section of pipe removed. In order to estimate biomass, samples of *Hiatella arctica* (Linnaeus, 1758) and *Mytilus edulis* Linnaeus, 1758 were dried at 100° C until their weight was constant.

In areas inaccessible to direct examination, x-rays of the PVC pipes were taken with a Hotshot portable industrial unit, made by Picker X-ray Corporation. A fine grained, slow film was used, (Kodak X-ray film for Mammography MA-2, size 20.3 × 25.4 cm). The exposures were 90 kilovolts with variation in milliampere-seconds and distance. Usually, animals less than 3 mm in size or those which were soft bodied, did not show up in the x-rays. However, the most common animals in the pipes were those with shells and these were quite visible. Therefore, it is these animals, mainly *Hiatella arctica, Mytilus edulis, Balanus* spp. and *Anomia simplex,* which are referred to when the amount of fouling growth in a pipe is described by x-radiography.

Under a light proof cover a configuration of transparent 5 cm diameter acrylic tubing was connected to the main system in mid-June 1971 and examined at weekly intervals for growth.

A section of new 5 cm PVC was installed in the sea water system (at A in Figure 2) January 1971 and removed December 1971, thus receiving one years exposure.

Estimates of water flow were obtained in August by observing the filling time of a suitable container held under each outfall. As water flow varied with its usage, both daily, and in previous years, only water velocities which are representative have been included. It should be remembered that alteration of flow in any particular laboratory would have only a minor effect on flows within the main pipes supplying the whole laboratory complex. Water velocity was calculated by dividing the flow rate by the cross-sectional area of the pipe.

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OBSERVATIONS

A number of general observations were made which apply to the whole seawater system. All primary fouling must have entered the system as larvae or juveniles, which passed through the rotary pumps. By microscopic examination of the water, a variety of plankton and debris were observed to pass through the entire system, and were thus available as a source of food for the fouling animals and as a source of new colonizers in the system. Algae did not grow in the system due to the lack of light. All surfaces in contact with seawater were covered with a brown slime or primary film, composed of filamentous fungus and numerous species of filamentous bacteria.

The fouling found in the seawater system is described by following, in sequence, the route taken by water, from intake in the pump house to discharge in laboratories. The inside diameter is given when referring to pipe size.

A submarine cavern positioned on the shoreline and open to the turbulent coastal water of Logy Bay, supplied water to the pump house via 15 cm diameter pipes which extend into the cavern.

Except for the sieve-like intake ends, these pipes were relatively clean. Similarly, the 10 cm diameter pipes (Fig. 1) which transport water between pump house and reservoir, appeared bare in the x-rays. In a direct examination only a few spirorbid worms were seen. Estimated water velocity from measurements and a reliable figure over the previous four year period was 85–124 m per minute.

The top of the water column in the concrete reservoir was 32 m above sea level. A gravity feed system drawing water from the bottom of the reservoir, supplied water to the main laboratory. The reservoir was 3.35 m deep and partitioned into two halves, each side holding approximately 22 000 l (5 500 USG). More species of invertebrates were found in the reservoir (Table 1) than elsewhere in the system. Spirorbids, tunicates and ectoprocts were most common on the fiber-glass walls, while in the mud and debris of the bottom, the brittle star *Ophiopholis aculeata* and the apodus sea cucumber *Chirodata laevis* were abundant. Mature sea urchins, crabs and starfish were also present.

Examination of the 15 cm diameter outflow pipe, which drains water from the bottom of the reservoir, revealed a solid build-up of organisms, 2–3 cm thick, around the inside circumference of the sieve-like intake. *Mytilus edulis* was dominant. Between the reservoir and the basement of the main laboratory, fouling, as observed by x-rays, was present along the entire length of these pipes, being heaviest in the section leaving the reservoir and lightest in the basement. Water velocity here varied from 21 to 37 m per minute depending on the use of the salt water evaporator.

The 10 cm diameter vertical pipes (velocity 46 m per minute) between the laboratory basement and 10 cm

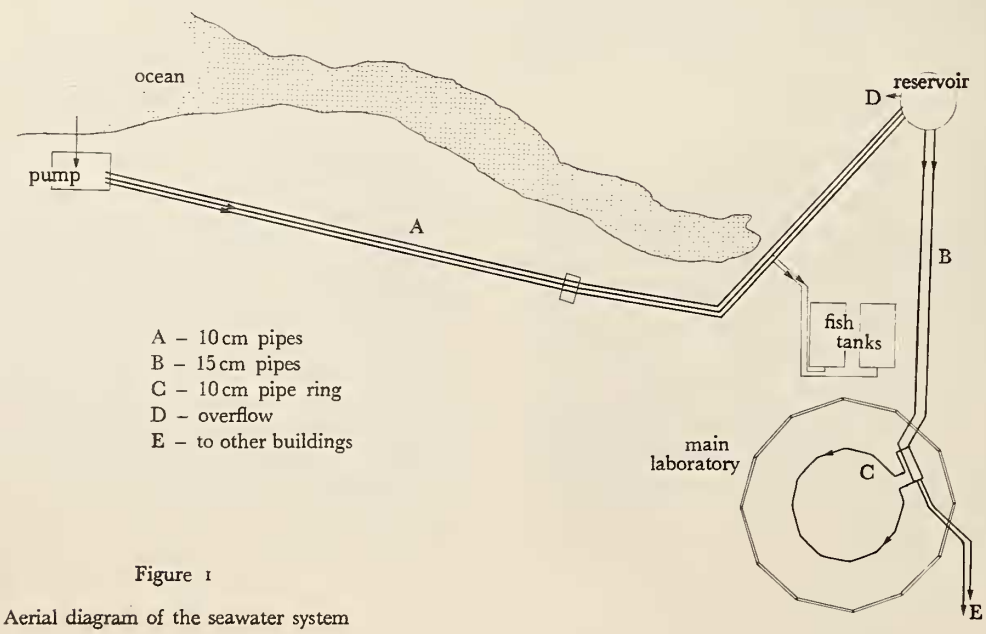

Figure 1

Aerial diagram of the seawater system